3.3.2 PROFILING HAZARD PROFILES

The following section profiles historical occurrences of those natural hazards previously identified as affecting Louisville (see section titled, Identifying Hazards). Due to Louisville's geology, climate, and geographical setting, the metro area is vulnerable to a wide array of natural hazards that threaten life and property.

Through research of the Louisville Metro Emergency Operations Plan (EOP), historic impacts, past federal disaster declarations, NCDC and Sheldus databases, newspaper and web searches, dollar losses to date, and discussions with key agencies, twelve hazards are identified in the Plan.

The Louisville Metro Hazard Profiles have been created using the best available data from a variety of resources, including but not limited to the National Climatic Data Center (NCDC), National Weather Service (NWS), LOJIC, Corps of Engineers: Louisville District, Kentucky Office of Geographical Information, Kentucky Geological Survey (KGS), Kentucky State Climatology Center, Midwestern Regional Climate Center (MRCC), FEMA Hazard Mapping website, local agencies and newspaper articles, and the approved Kentucky State Hazard Mitigation Plan .

Project Staff also used the FEMA Local Mitigation planning "How To Guide" series to guide the planning committees in the planning process. GIS hazard maps, damage history spreadsheets, and historical documentation are used to profile each event.

During the planning process, public input from the planning committees led to the creation of Profile Maps that document and illustrate where the Hazard prone areas are in Louisville Metro. Public input was an invaluable local resource in the planning process. Committee members attended meetings and discussed information gathered from the sources listed above. Committee members also discussed particular issues such as, past events and significant occurrences that did not warrant a declared disaster and how those events impacted the community.

Limited or no available data to conduct a complete hazard profile: The Planning Team and Advisory Committee identified 12 hazards to address in this Plan. Of the 12 hazards, there is one, wildfire, where there is little historical data. The Planning Committees chose to include this hazard because it is listed in the EOP as a hazard as possible and probable in Louisville Metro. Although it is impossible to profile this hazard in the detail required by the DMA 2000 guidelines and regulations, the committee has chosen to address mitigation strategies for wildfire.

Past disaster damage information was provided to Project Staff by the state hazard mitigation office. The following table is the Louisville Metro summary of past Declared Disasters, provided by FEMA. Throughout the plan, reference will be made to this table as the hazard events are profiled.

Louisville Metro Declared Disasters

DR #	Declaration Date	Disaster Type	# of KY Declared Counties
420	4/4/1974	Tornadoes	34
568	12/12/1978	Severe Storms, Flooding	37
821	2/24/1989	Severe Storms, Flooding	67
1089	1/13/1996	Blizzard	120
1163	3/4/1997	Flooding	101
1471	6/3/2003	Landslide, Severe Storm, Tornado, Flooding	44

How the Profiles Are Setup

The following sections provide a "profile" of each identified hazard in the Louisville Metro area. This portion of the plan identifies the following information:

- A risk factor table and hazard risk gauge, which summarize the overall risk.
- A description of each identified hazard and potential impact.
- Historical background on each identified hazard and a brief description of known events.
- Profile Maps, if applicable, of the locations and areas affected by Hazard events. Maps are a key component for communication with the Planning Team, Advisory Committee, Metro Council, and at the public meetings. Hazard maps also will assist in determining the mitigation strategy.

> *Risk factors* are characteristics of a hazard that contribute to the potential losses that may occur in the area.
>
> The *hazard risk gauge* is a graphic icon used during the initial profile ranking process to convey the relative risk of a given hazard. The scale ranges from green, indicating relatively low or no risk, to red, indicating severe risk.

BACKGROUND

Louisville Metro Climate

Louisville's climate is described as "moist-continental". Winters are moderately cold with temperatures rarely below zero degrees Fahrenheit, with January being the coldest month. Average annual snowfall is about 17 inches. Summers are hot (although rarely above 100 degrees Fahrenheit) and humid, with July being the hottest month. Spring and summer months are characterized by changeable, wet weather. March has the greatest total rainfall. Yearly precipitation is approximately 43 inches. The driest month is October.

The climate of Louisville, while continental in type, is of a variable nature because of its position with respect to the paths of high and low pressure systems and the occasional influx of warm moist air from the Gulf of Mexico. In winter and summer, there are occasional cold and hot spells of short duration. As a whole, winters are moderately cold and summers are quite warm. Temperatures of l00 degrees or more in summer and zero degrees or less in winter are rare. Thunderstorms with high rainfall intensities are common during the spring and summer months. The precipitation in Louisville is nonseasonal and varies from year to year. The fall months are usually the driest. Generally, March has the most rainfall and October the least. Snowfall usually occurs from November through March. As with rainfall, amounts vary from year to year and month to month. Some snow has also been recorded in the months of October and April. Mean total amounts for the months of January, February, and March are about the same with January showing a slight edge in total amount. Relative humidity remains rather high throughout the summer months. Cloud cover is about equally distributed throughout the year with the winter months showing somewhat of an increase in amount. The percentage of possible sunshine at Louisville varies from month to month with the greatest amount during the summer months as a result of the decreasing sky cover during that season. Heavy fog is unusual and there is only an average of l0 days during the year with heavy fog and these occur generally in the months of September through March.

The average date for the last occurrence in the spring of temperatures as low as 32 degrees is mid-April, and the first occurrence in the fall is generally in late October.

The prevailing direction of the wind has a southerly component and the velocity averages under l0 mph. The strongest winds are usually associated with thunderstorms.

Louisville Metro Watersheds

Jefferson County has eleven major stream systems: Mill Creek, Pond Creek, South Fork Beargrass Creek, Middle Fork Beargrass Creek, Muddy Fork Beargrass Creek, Goose Creek, Harrods Creek, Floyds Fork, Cedar Creek, Pennsylvania Run and Ohio River. Approximately 790 miles of streams are found within these six stream systems. The land drained by each of these streams is called a "watershed."

Louisville Metro Topography

Louisville is located on the south bank of the Ohio River, 604 miles below Pittsburgh, Pennsylvania, and 377 miles above the mouth of the river at Cairo, Illinois. The city is divided by Beargrass Creek and its south fork into two portions with entirely different types of topography. The eastern portion is rolling, containing several creeks, and consists of plateaus and rolling hillsides. The highest elevation in this area is 565 feet.

The western portion is mostly flat with an average elevation about l00 feet lower than the eastern area. Much of the western section lies in the flood plain of the Ohio River.

Louisville Metro Geology

For Jefferson County, the geology consists of limestone, shale, and dolomite plus alluvial and lacustrine deposits. The five major geological areas are as follows:

1. The loam soils in the northeastern part of the county tend to overlie limestone, are relatively deep, and generally well drained. They are best suited for pasture.
2. The northern and western most parts of the county are adjacent to the Ohio River. The soils found within this area are well-drained alluvial soils with a silty sand texture. These floodplain soils represent some of the best agricultural soils in the county.
3. The central portion of the county is in poorly drained clay-based soils. Much of this area was once considered a wetland.
4. The geology within the southern part of the county is on steep slopes or upland areas. The soils are generally well-drained, moderate in depth, composed of shaly limestone or silty loam, and are best used for maintaining forested areas.
5. The southeastern part of the county is mostly hills, with moderate to steep slopes, and numerous sinkholes. The soils overlie limestone, and limestone fragments are commonly mixed into the soils. The soils are moderate to deep in most areas, generally well drained, and are a mixture of wind blown sediments, silt, loam, and clays. They are well suited for forest and pasture.

See Appendix 11 for a detailed list of background NCDC tables and data.

Dam / Levee Failure Profile

SUMMARY OF DAM FAILURE RISK FACTORS

Period of occurrence:	At any time
Number of Events to-date	0
Probability of event(s):	Infrequent. Dams that fail, historically, have some deficiency, which caused the failure. Chance of failure increases with heavy rain or earthquake.
Warning time:	Minimal, depends on frequency of inspection.
Potential Impact(s):	Impacts human life and public safety. Economic loss, environmental damage, and/or disruption of lifeline facilities
Cause injury or death	Injury and risk of multiple deaths
Responsible for Monitoring Dam Maintenance	State, MSD, Metro Parks, Corp of Engineers, private owner, and development community
Potential Facility Shutdown	30 days or more

Background: Since 1948, anyone in Kentucky proposing to construct a dam has been required to submit a plan to the state for review in order to obtain a permit. In 1966, Kentucky adopted a set of guidelines for evaluating dams. In 1974, the permit system was revised to include regular state inspection of dams. KRS 150.295 directs the Secretary of the Natural Resources and Environmental Protection Cabinet to inspect dams and reservoirs on a regular schedule.

In Kentucky

There are about 1,133 dams in Kentucky. The MSHA has identified 121 impoundments in Kentucky and 60 of those as "high hazard" structures.

The Dam Safety and Security Act of 2002 (Public Law 107-310): signed into law on December 2, 2002, addresses safety and security for dams through the coordination by FEMA of federal programs and initiatives for dams and the transfer of federal best practices in dam security to the states. The Act of 2002 includes resources for the development and maintenance of a national dam safety information network and the development of a strategic plan that establishes goals, priorities, and target dates to improve the safety and security of dams in the US.

Potential Damage by Dam Failure: Dam-and Levee-Failure Flooding is potentially the worst flood events. A dam failure is usually the result of neglect, poor design, or structural damage caused by a major event such as an earthquake. When a dam fails, an excess amount of water is suddenly let loose downstream, destroying anything in its path. Many dams and levees are built for flood protection and usually are engineered to withstand a flood with a computed risk of occurrence. For example, a dam or levee may be designed to contain a flood at a location on a stream that has a certain probability of occurring in any one year. If a larger flood occurs, then that structure may be overtopped. If during the overtopping the dam or levee fails or is washed out, the water behind it is released and becomes a flash flood. Failed dams or levees can create floods that are catastrophic to life and property because of the tremendous energy of the released water.

Likelihood of Occurrence: Signs of Potential Dam Failure

- *Seepage.* The appearance of seepage on the downstream slope, abutments, or downstream area is cause for concern. If the water is muddy and is coming from a well-defined hole, material is probably being eroded from inside the embankment and a potentially dangerous situation can develop.
- *Erosion.* Erosion on the dam and spillway is one of the most evident signs of danger. The size of erosion channels and gullies can increase greatly with slight amounts of rainfall.
- *Cracks.* Cracks are of two types: transverse and longitudinal. Transverse cracks appear perpendicular to the axis of the dam and indicate settlement of the dam. Longitudinal cracks run parallel to the axis of the dam and may be the signal for a slide, or slump, on either face of the dam.
- *Slides and Slumps.* A massive slide can mean catastrophic failure of the dam. Slides occur for many reasons and their occurrence can mean a major reconstruction effort.
- *Subsidence.* Subsidence is the vertical movement of the foundation materials due to failure of consolidation. Rate of subsidence may be so slow that it can go unnoticed without proper inspection. Foundation settlement is the result of placing the dam and reservoir on an area lacking suitable strength, or over collapsed caves or mines.
- *Structural.* Conduit separations or ruptures can result in water leaking into the embankment and subsequent weakening of the dam. Pipe collapse can result in hydraulic failures due to diminished capacity.
- *Vegetation.* A prominent danger signal is the appearance of "wet environment" types of vegetation such as cattails, reeds, mosses and other wet area vegetation, which can be a sign of seepage.
- *Boils.* Boils indicate seepage water exiting under some pressure and typically occur in areas downstream of the dam.
- *Animal Burrows.* Animal burrows are a potential danger since such activity can undermine the structural integrity of the dam.
- *Debris.* Debris on dams and spillways can reduce the function of spillways, damage structures and valves, and destroy vegetative cover.

Historical Impact: In Kentucky, there have been six dam failures reported to the National Performance Dam Program, none in Louisville Metro. Dams are classified based on the evaluation of damage possible downstream. The FEMA guide to dam classifications uses the following system:

Classification of Dams	
Classification	**Description**
Class A (Low)	No loss of human life is expected and damage will only occur to the dam owner's property
Class B (Moderate/Significant)	Loss of human life is not probable, but economic loss, environmental damage, and/or disruption of lifeline facilities can be expected
Class C (High)	Loss of one or more human life is expected
(Source: FEMA 333; Federal Guidelines for Dam Safety, Hazard Potential Classifications for Dams, October 1998)	

Types of Dam Failures

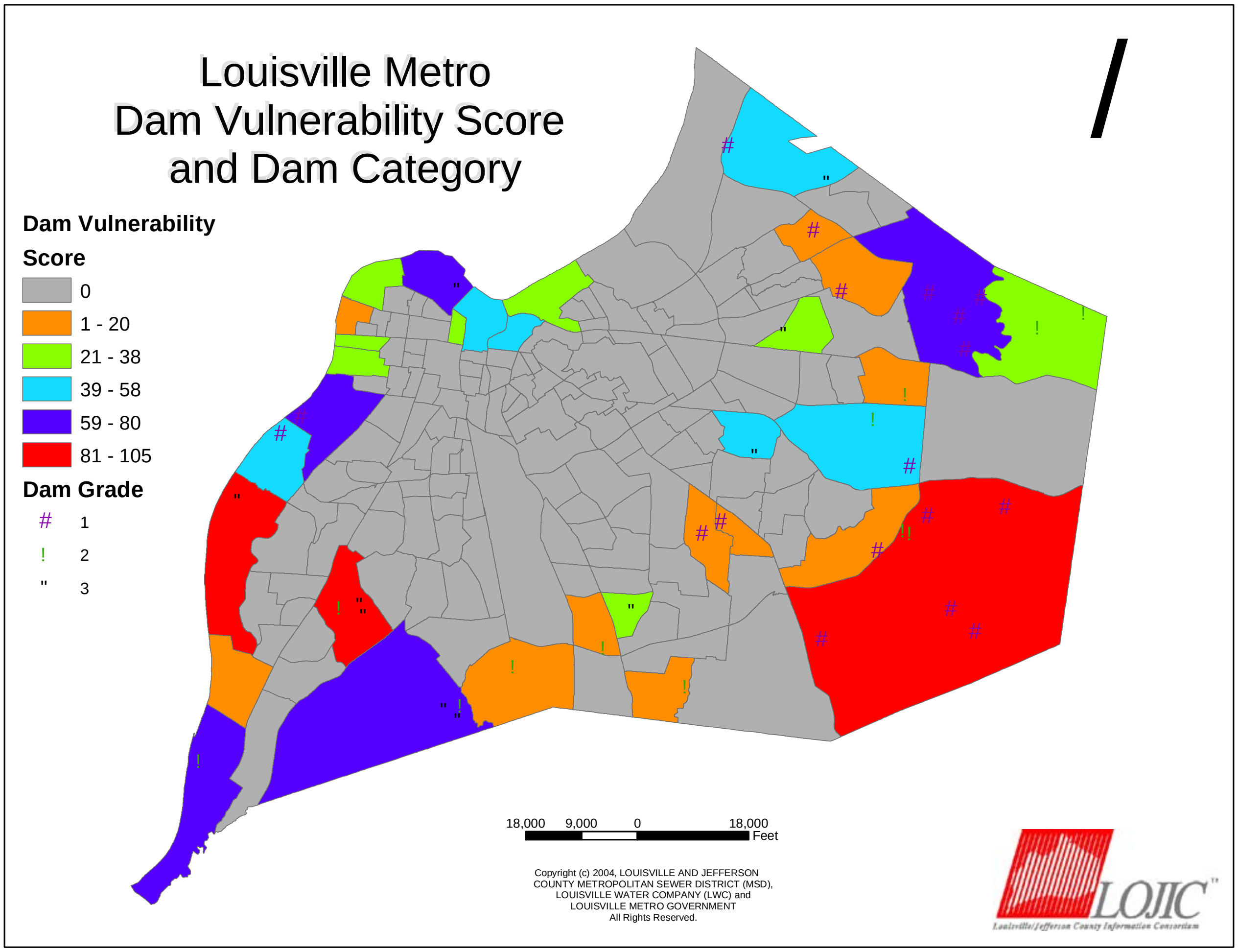
- *Hydraulic Failure.* Hydraulic failures result from the uncontrolled flow of water over the dam, around the dam and adjacent to the dam, and the erosive action of water on the dam and its foundation. Earth dams are particularly vulnerable to hydraulic failure since earth erodes at relatively small velocities.
- *Seepage Failure.* All dams exhibit some seepage that must be controlled in velocity and amount. Seepage occurs both through the dam and the foundation. If uncontrolled, seepage can erode material from the foundation of an earth dam to form a conduit through which water can pass. This passing of water often leads to a complete failure of the structure, known as piping.
- *Structural Failure.* Structural failures involve the rupture of the dam and/or its foundation. This is particularly a hazard for large dams and for dams built of low strength materials such as silts, slag, fly ash, etc. Dam failures generally result from a complex interrelationship of several failure modes. Uncontrolled seepage may weaken the soils and lead to a structural failure. Structural failure may shorten the seepage path and lead to a piping failure. Surface erosion may lead to structural or piping failures.

Following is an inventory of Louisville Metro dams maintained by the U.S. Army Corps of Engineers and the Kentucky Cabinet for Natural Resources and Environmental Protection, Division of Water. The nine Class C dams are at the highest risk and are required to have an emergency action plan, which is maintained by the dam owner.

Dam Inventory for Louisville Metro

Summary of Dams Class A, B & C			
	Class A (low)	Class B (moderate)	Class C (high)
STATE	18	12	9
USACE			1
		TOTAL	40

Following is a map of the dams located in Louisville Metro.



Map by LOJIC, 2005

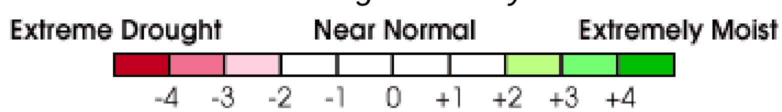
Drought Profile

SUMMARY OF DROUGHT RISK FACTORS

Period of occurrence:	Summer months or extended periods of no precipitation.
Number of Events to-date 1895- 2004	28
Probability of event(s):	Infrequent
Warning time:	Weeks
Potential Impact(s):	Activities that rely heavily on high water usage may be impacted significantly, including agriculture, tourism, wildlife protection, municipal water usage, commerce, recreation, electric power generation, and water quality deterioration. Droughts can lead to economic losses such as unemployment, decreased land values, and Agro-business losses. Minimal risk of damage or cracking to structural foundations, due to soils.
Cause injury or death	No
Potential Facility Shutdown	None

Background: Louisville Metro is located in Division 2 according to the four climate zones set for Kentucky. Drought is measured by the

Palmer Drought Severity Index



Louisville Metro Drought History: Research includes: local NWS, EMA, and newspaper archives. Below is the NWS data for Division 2 outlining all moderate to severe droughts, occurring during 1895 – 2004.

Palmer Classifications System (PDSI)	
-2.0 in to -2.99 in	Moderate drought
-3.0 in to -3.99 in	Severe drought
-4.0 in or less	Extreme drought
(Source: National Oceanic and Atmospheric Association (NOAA))	

Kentucky, Division 02
Palmer Drought Severity Index for Drought
1895- 2004

Years of Moderate Drought:
2.0 – 2.99 PDSI

1895
1896
1897
1899
1900
1903
1906
1919
1921
1922
1925
1959
1980
1981
1986
1987
1991
1998
2001

19 YEARS TOTAL

Years and PDSI for Severe Drought:
3.0 & above PDSI
Year/Month/PDSI

1901
07 -3.58
08 -3.26
11 -3.32
12 -3.00

1902
08 -3.36

1904
10 -3.22
11 -4.04
12 -3.80

1905
01 -3.78
02 -3.63
03 -3.58
04 -3.68

1908
-12 -3.26

1909
- 01 -3.12

1913
08 -3.10
09 -3.26
11 -3.23
12 -3.52

1914
01 -3.73
05 -3.12
06 -3.68
07 -4.01
08 -3.30

1915
04 -3.27

1930
07 -4.16
08 -4.76
09 -4.76
10 -5.19
11 -5.75
12 -6.30

1931
01 -6.67
02 -6.63
03 -6.21
04 -5.56
05 -5.57
06 -5.61
07 -6.00
08 -5.25
09 -5.20
10 -4.81
11 -4.77

1934
12 -3.07

1936
06 -3.07
07 -3.63
08 -4.50
09 -4.23
10 -3.95
11 -4.02

1939
12 -3.23

1940
01 -3.67
02 -3.02
10 -3.54
11 -3.27
12 -3.26

1941
01 -3.34
02 -3.86
03 -4.31
04 -4.19
05 -4.78
06 -4.14
07 -3.69
08 -3.48
09 -4.18
10 -3.71
11 -3.78
12 -3.81

1942
01 -3.57
02 -3.43
03 -3.24
04 -3.22
05 -3.00

1943
12 -3.13

1944
01 -3.66
02 -3.30
06 -3.15
07 -3.85

1952
11 -3.40
12 -3.55

1953
01 -3.22
02 -3.53
09 -3.60
10 -4.25
11 -4.94
12 -5.41

1954
01 -4.64
02 -4.67
03 -5.01
04 -4.63
05 -4.42
06 -4.34
07 -4.86
08 -4.52
09 -4.05
10 -3.80
11 -4.20
12 -3.90

1955
01 -4.15

1963
12 -3.42

1964
01 -3.41
02 -3.44

1988
06 -3.34

1999
08 -3.07
09 -3.48
10 -3.31
11 -3.96
12 -4.12

2000
01 -3.84
02 -3.41
03 -3.53

28 YEARS TOTAL

Drought Potential Impacts: High temperatures, prolonged high winds, and low relative humidity can aggravate drought conditions. In Louisville Metro, a secondary effect of a drought could be low river levels on the Ohio River. Low water can become unsafe for navigation in some areas. As a result, fully loaded barges may not be able to safely navigate the river, and tonnage may have to be reduced by 10 to 20 percent.

During periods of drought, some activities that rely heavily on high water usage may be impacted significantly. These activities include agriculture, tourism, wildlife protection, municipal water usage, commerce, recreation, wildlife preservation, electric power generation, and water quality deterioration.

Droughts can lead to economic losses such as unemployment, decreased land values, and Agro-business losses. In addition, there is minimal risk of damage or cracking to structural foundations, due to soils.

Earthquake Profile

SUMMARY OF EARTHQUAKE RISK FACTORS

Period of occurrence:	Year-round
Number of Events to-date	0 epicenter occurrences in Louisville Metro, however regional events have affected the area.
Probability of event(s):	Infrequent
Warning time:	None
Potential Impact(s):	Impacts human life, health, and public safety. Utility damage and outages, infrastructure damage (transportation and communication systems), structural damage, fire, damaged or destroyed critical facilities, and hazardous material releases. Can cause severe transportation problems and make travel extremely dangerous. Aftershocks and secondary events could trigger landslides, releases of hazardous materials, and/or dam and levee failure and flooding.
Cause injury or death	Injury and risk of multiple deaths.
Potential Facility Shutdown	Months

Background: Specific fault systems in Kentucky include the Rough Creek and Pennyrile Fault Systems, running east-west to the southwest of the Louisville Metro area, and the Cincinnati Arch that runs roughly north-south through Lexington some 75 miles to the east.

In general, these faults have been inactive for thousands of years. Earthquakes may occur in areas where faults have not yet been identified; this situation presented itself when an earthquake occurred in Sharpsburg in 1980 in an area previously not known to include a fault.

In Kentucky

Earthquakes can be experienced in any part of Kentucky, putting Kentucky's entire population and building stock at risk. Each county has at least one fault running beneath it.

Historical Impact: Thousands of minor earthquakes have occurred in and around Kentucky in the New Madrid seismic zone in the west, to Greenup County in the northeast, and in Bell County in the Southeast. Earth tremors also have been recorded (for example, a series of these tremors occurred in April 1974). Since 2000, several minor earthquakes have been felt in the Louisville Metro.

Major earthquake events have occurred. From December 1811 through February 1812, the New Madrid Fault experienced three earthquakes, each of which was over a “magnitude” of 8. These quakes were accompanied by a series of aftershocks, at least 15 of which were felt as far away as Washington DC (LMEMA 2003).

The University of Memphis estimates that, for a 50-year period, the probability of a repeat of the New Madrid 1811-1812 earthquakes with:

- A magnitude of 7.5 - 8.0 is 7 to 10%
- A magnitude of 6.0 or larger is 25 to 40%

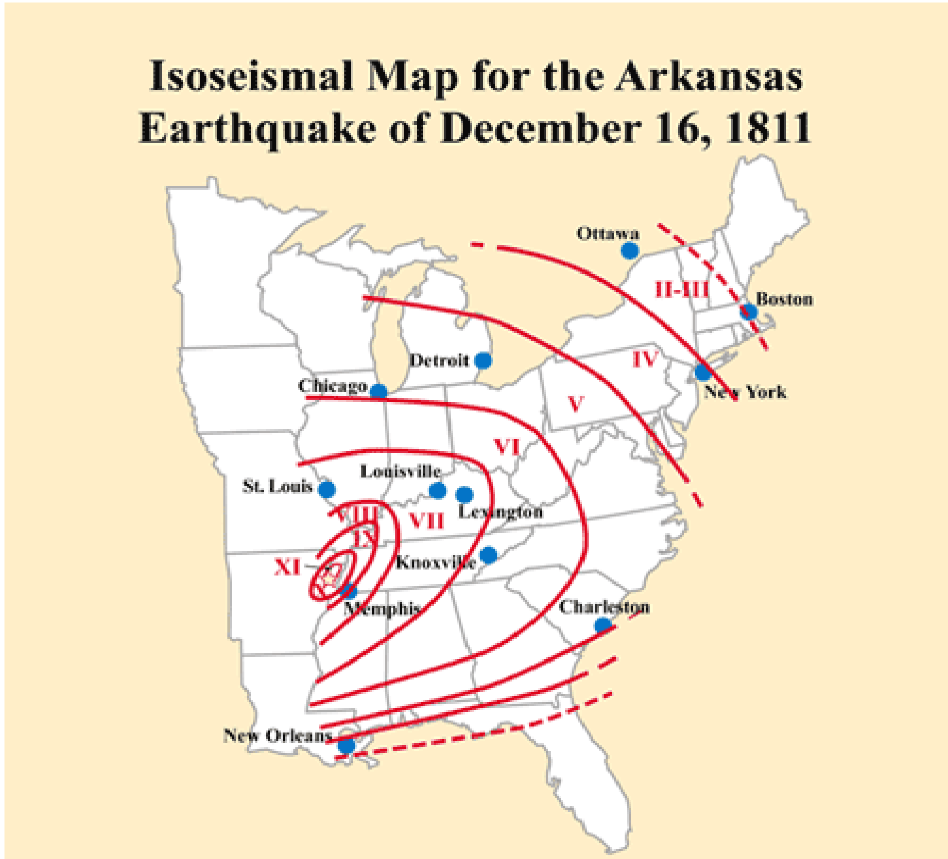
Louisville Metro Potential Earthquake Damage: Seismic events generate energy waves that attenuate as they move away from the epicenter of the event. The nature of the crustal rock of the Central U.S. results in a low degree of wave attenuation. Therefore, seismic shocks that occur in the central portion of the U.S. will affect a far greater area than similar events on the western coast.

The HAZUS-MH pilot program results show that an earthquake of 8.6 M in the New Madrid seismic zone would result in structural building damage ranging from minor to significant extending well into the Louisville Metro area. A similar earthquake magnitude event in the western U.S. would impact a much more limited geographic area. Earth scientists estimate that enough energy has built up in the New Madrid seismic zone to produce an earthquake with a 7.6*M*. Everyone in Kentucky could feel such a quake, while the Louisville Metro area would experience the effects at a Modified Mercalli Intensity Zone 7 (LMEMA 2003). The effects of such an earthquake could include: (1) ruptured pipelines, (2) downed electrical and communication lines, (3) releases of hazardous materials, (4) fires, (5) collapsed bridges and overpasses, and (6) damaged or destroyed critical facilities. See Appendix 12 for the HAZUS-MH pilot project results for earthquake.

Damage associated with the major earthquakes in 1811 and 1812 was not significant due to the low level of development in the area at the time. However, today over 12.5 million people live in the region impacted by the 1811 to 1812 events.

Damage associated with the Sharpsburg earthquake was $3 million (largely located in Maysville, Kentucky, rather than at the epicenter in Sharpsburg) (LMEMA 2003).

Areas of softer soil and potential liquefaction generally result in increased vulnerability to the impacts of an earthquake. In Louisville Metro, old portions of the city and heavy industry are located on the alluvial deposits adjacent to the Ohio River. New portions of the city, including malls and the surrounding suburbs are constructed on the clay materials derived from limestone bedrock (ULY CIR 2004).



Modified Mercalli Intensity Scale

INTENSITY		EFFECTS	AVE. PEAK ACCELERATION
VI	Strong	Felt by all. Damage slight.	0.06–0.07g
VII	Very Strong	Everybody runs outdoors. Considerable damage to poorly designed buildings.	0.10–0.15g
VIII	Destructive	Considerable damage to ordinary buildings.	0.25–0.30g
IX	Ruinous	Great damage to ordinary buildings	0.50–0.55g
X	Disastrous	Many buildings destroyed.	>0.60g
XI	Disastrous	Few, if any, structures remain standing	

(Simplified from Bolt, 1993)

(Source: Kentucky Geological Survey)
http://www.uky.edu/KGS/geologichazards/eqinky.htm)

As part of the pilot project, available soil maps were obtained from the Kentucky Geological Survey (KGS 2004). Data for approximately one-third of the study area was available and was applied to evaluate the risk to buildings and infrastructure.

Extreme Heat Profile

SUMMARY OF EXTREME HEAT RISK FACTORS	
Period of occurrence:	Summer
Number of Events to-date:	9 events during 1952 to 2005 6 deaths 1999- 2002
Probability of event(s):	Likely
Warning time:	Several days of high temperatures hovering over 90 degrees.
Potential Impact(s):	Public health and safety, especially the elderly. Heavy use of water and electrical facilities due to air conditioners, fans, etc…
Cause injury or death	Injury and risk of multiple deaths
Potential Facility Shutdown	None

Background: Temperatures that hover 10 degrees or more above the average high temperature for the region are defined by NOAA as extreme heat. A temperature of 90°F is significant in that it ranks at the "caution" level of the NOAA's Apparent Temperature chart even if humidity is not a factor.

July 1999 Heat Wave

During the last two weeks of July 1999, the Midwest experienced a lengthy series of days with temperatures in excess of 90F. Before it was over, some 232 deaths were attributed to the heat in the 9-state Midwest region.

Extreme Heat Impacts: Main impacts are to public health and safety, especially the elderly. Additionally, heavy use of utilities (electric and water) cause a strain on the system due to air conditioners, fans, and water usage, etc…

Kentucky Historical Climate Data: Data from a thirty-year time span of 1970-1999 was obtained from the Kentucky Climate Center for 52 in-state and 13 out-of-state sites. This data showed the mean amount of days that temperatures rose to or beyond 90°F. The map below shows Kentucky's normal occurrence of days when temperatures equal or exceed 90°F.

History of Extreme Heat In Louisville Metro: Research has shown there is limited Louisville Metro data for tracking the damages, injuries, or deaths for extreme heat. Death certificates kept by the Jefferson County Health Department show six deaths due to extreme heat occurred during 1999 - 2002. These deaths occurred as following: four in 1999, 1 in 2000, and 1 in 2002.

Following is information from the NWS indicating time periods and number of days during 1888 to 2005 when the temperature rose above 100 degrees.

LOUISVILLE AIRPORT
1952 - 2005

Conditions that are Maximum Temperature greater than or equal to 100 deg F

Time Period			> # of days
07/26/1952	to	07/28/1952	3
08/31/1953	to	09/02/1953	3
07/12/1954	to	07/14/1954	3
09/04/1954	to	09/06/1954	3
07/21/1983	to	07/23/1983	3
08/20/1983	to	08/22/1983	3
07/07/1988	to	07/10/1988	4
07/29/1999	to	07/31/1999	3
08/03/2002	to	08/05/2002	3
TOTAL 9 events			

1999 Heat Wave

During the last two weeks of July 1999, the Midwest experienced a lengthy series of days with temperatures higher than 90 degrees F. While only a relatively small number of maximum temperature records were set, the combination of high heat, record dew points, strong solar inputs, and weak winds led to a dangerous situation for people. Before it was over, some 232 deaths were attributed to the heat in the 9-state area served by the MRCC; there were additional health, infrastructure, and economic impacts that were quite significant.

Louisville Metro

The Jefferson County Health Department reported four (4) deaths due to extreme heat in 1999.

The major loss of life was in large cities where the urban heat island amplified temperatures by 3 to 5 degrees or more. The majority of those who died were elderly persons, living alone in the inner city regions, and either were without air conditioning or without the funds to pay for continuous operation of their air conditioning units. Most of the people who died on the 29th and 30th lived in large cities with an old infrastructure of non-air-conditioned brick buildings. A comparison of hourly temperatures between stations inside large cities and nearby suburban stations demonstrates the strong urban heat island affects during the heat wave.

Flood Profile

SUMMARY OF FLOOD RISK FACTORS

Period of occurrence:	Ohio River: January through May Flash floods: anytime, but primarily during Summer rains
Number of Events to-date: 1832 - 2004	40+
Probability of event(s):	Highly likely
Warning time:	River flooding – 3 –5 days Flash flooding – minutes to hours Out-of-bank flooding – several hours/days
Potential Impact(s):	Impacts human life, health, and public safety. Utility damage and outages, infrastructure damage (transportation and communication systems), structural damage, fire, damaged or destroyed critical facilities, and hazardous material releases. Can lead to economic losses such as unemployment, decreased land values, and Agro-business losses. Floodwaters are a public safety issue due to contaminants and pollutants.
Cause injury or death	Injury and risk of multiple deaths
Potential Facility Shutdown	Weeks to months

Background: Flooding is probably the most significant natural hazard in Kentucky. Major flooding occurs within the state almost every year and it is not unusual for several floods to occur in a single year.

Kentucky Flood Related Presidential Declarations: Flooding is Kentucky's most costly natural disaster. About 300 communities have identified flood-prone areas. For many, the economic, social, and physical damage resulting from floods can be severe. The following is a list of flood-related Presidential Declarations in Kentucky from 1970 to 2002. Only major disasters are included; numerous isolated events are not listed.

In Kentucky

Flooding is common along Kentucky's major waterways, particularly the Kentucky, Green, Licking, Ohio, and Mississippi Rivers. Cities such as Frankfort, Louisville, Owensboro, and Paducah have been seriously affected by flooding.

Flood Presidential Declarations in Kentucky (1970-2002)	
Date	Number of Counties
February 2, 1970	12
June 5, 1970	13
May 15, 1972	10
March 29, 1975	17
April 6, 1977	15
December 12, 1978	37
May 15, 1984	23
February 24, 1989	67
June 30, 1989	12
October 30, 1989	11
January 29, 1991	19
March 16, 1994	68
June 13, 1995	69
March 3, 1997	101
August 15, 2001	20
April 4. 2002	30
May 7, 2002	32

(Source: Kentucky Division of Emergency Management)

Potential Flood Impacts: Flooding impacts human life, health, and public safety. Community-wide the potential for risks is severe for: utility damage and outages, infrastructure damage (transportation and communication systems), structural damage, fire, damaged or destroyed critical facilities, and hazardous material releases. Flooding also can lead to economic losses such as unemployment, decreased land values, and Agro-business losses.

Analysis performed for the Floodplain Management Plan indicated the watersheds with the greatest risk for loss of life and/or property damage relative to number of buildings and primary structures is Pond Creek, Beargrass Creek, and Mill Creek. Based on an analysis of repetitive loss sites, the North County watershed represents an area of extraordinary high risk, although there are a relatively low total number of structures in the floodplain.

Floodplain Management Plan

The local floodplain management plan (FPMP) adopted in 2001 estimated the total buildings at risk for the 100-year flood as approximately 6 percent. This result aligns with the HAZUS-MH result (approximately 6.8 percent of buildings).

History of Flooding in Louisville Metro: The following table shows the flood-related Presidentially Declared Disasters for Louisville Metro.

Disaster Number	Declaration Date	Disaster Type
568	12/12/1978	Severe Storms, Flooding
821	2/24/1989	Severe Storms, Flooding
1163	3/4/1997	Flooding
1471	6/3/2003	Flooding, Landslide, Severe Storm, & Tornado

Newspaper accounts and historical records show that during the 19th century large floods occurred in 1832, 1847, 1859, 1867, 1883, and 1884. Major floods in the 20th century have occurred in 1907, 1913, 1933, 1937, 1945, 1948, 1964, and 1997. Thus, it can be seen that serious flooding has occurred in the Louisville area on the average of about once every 10 years.

Ten Greatest Recorded Flood Events of the Ohio River		
Month	Year	NGVD Elevation Upper Gauge
February	1883	447.5
February	1884	449.7
January	1907	444.4
January	1913	442.5
April	1913	447.4
January	1937	460.2
March	1945	450.1
April	1948	444.0
March	1964	449.2
March	1997	445.1

The normal elevation of the upper pool of the Ohio River is approximately 420' above mean sea level (NGVD). Overbank flooding occurs at approximate elevation 431', and the base flood elevation (BFE) varies between 443' and 455'.

In general, the two most common types of flooding that occur in Louisville Metro area are flash floods and Ohio River flooding.

- *Flash flooding* occurs in all parts of the state as the result of excessive rainfall over a short time. Flash floods can happen any time of the year, but are more prevalent during spring and summer months.
- *River basin flooding* is more common during winter and early spring.

The major flooding problem in Louisville/Jefferson County is related to out-of-bank flooding. Out-of-bank flooding is defined as flooding that occurs when the natural embankments of a watercourse are breached. Additionally, ponding also may result in certain areas, at their lowest elevations. The community is also vulnerable to other flooding situations due to street runoff, erosion, and sewer and drainage problems.

The main flood season for the Ohio River is between the months of January and May. All of the highest floods on record have resulted from general heavy rains throughout the Ohio River Basin. In both summer and fall, intense local thunderstorms also can contribute significantly to local flash flooding and interior drainage problems.

National Flood Insurance Program

Louisville and Jefferson County both became an NFIP (National Flood Insurance Program) community in 1978/79. The Flood Insurance Rate Maps (FIRM), updated in 1994, are used to enforce floodplain regulations and the local floodplain ordinance.

CRS Program

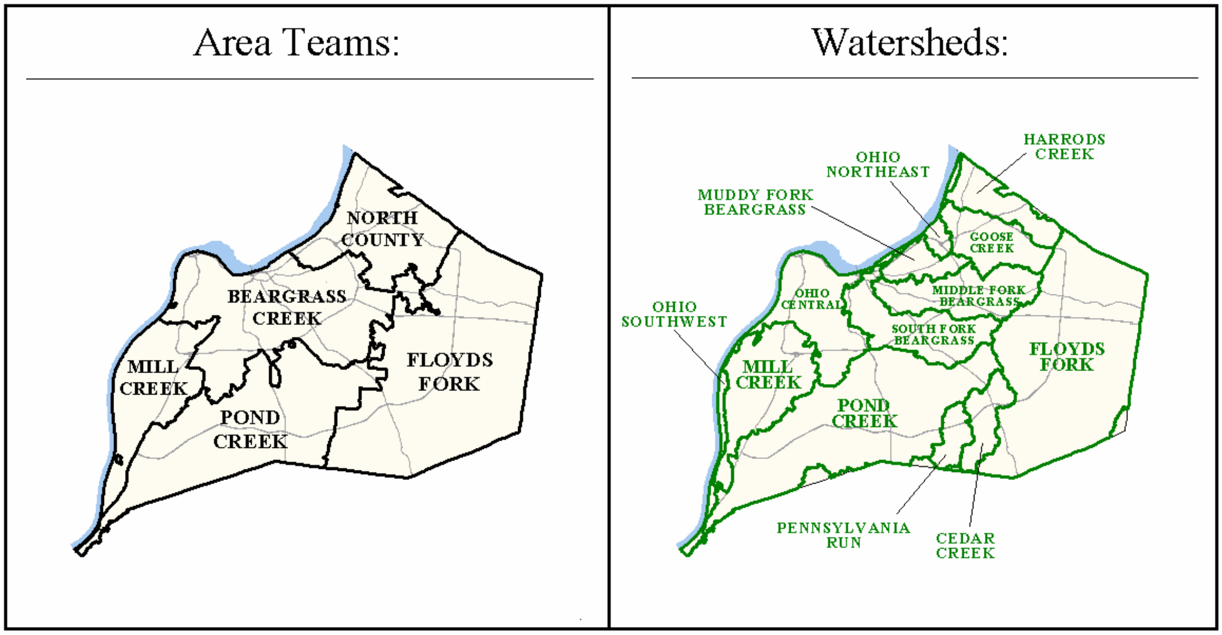
Beginning in 1990, both Louisville and Jefferson County volunteered to join the CRS (Community Rating System) Program. The Louisville/Jefferson County Metropolitan Sewer District (MSD) is the CRS Program Coordinator and is responsible for completion of all CRS activities. Since 2001, both the City of Louisville and Jefferson County rank a Class 6 Rating due to strong stormwater, floodplain, mapping, and emergency service programs. As a result, residents receive a 20% discount on flood insurance premiums. A Class 6 Rating is the highest-class rating in Kentucky.

The average duration of Ohio River floods of record in Jefferson County is about 12 days. However, the sustained flood duration in 1937 was 23 days, in 1945 it was 18 days, and in 1964 and 1997 it was 14 days. The rate of rise at levels above flood stage varies in relation to rainfall and runoff rates for specific storms. Typical rates of rise for the Ohio River, at levels above flood stage, range from 2.5 to 5 inches per hour with the record rate of rise being 4.7 feet in 12 hours and 8.4 feet in 24 hours in 1964.

Louisville Metro's Watersheds: In June 1997, MSD launched a watershed-based approach to managing its wastewater and stormwater programs. MSD's holistic overview of watershed management integrates service activities such as planning, enforcement, emergency management, best management practices, preservation, hydrology, hydraulics, and geography. The watershed approach also promotes a comprehensive effort to address multiple causes of water quality and habitat degradation in a watershed.

MSD recognizes that each watershed area presents its own set of challenges. For management purposes, MSD consolidated Louisville's 11 natural watersheds into five main management areas. The five areas are as follows: Pond Creek; Beargrass Creek, Floyds Fork; Mill Creek, and North County (see map below). MSD formed watershed management teams called Area Teams with the mission to be more responsive to MSD customers and to streamline the process of planning, design and construction of capital wastewater and stormwater projects.

Following is a map comparing the natural watersheds and MSD's Area Team Watershed approach.



Map from the Louisville/Jefferson County Floodplain Management Plan

Historical Flood Information by Watershed

> **Watershed**
>
> A watershed is a geographic area defined by boundaries that eventually drains into a single outlet, such as a stream or a creek. Water falling in any part of the watershed eventually finds its way through drainage swales, storm sewers and ditches, and into a tributary or major stream that flows out of the watershed. In Jefferson County, all streams eventually drain into the Ohio River.

Pond Creek was not heavily developed until the 1950's so the 1937 flood did not severely affect the area. Originally, much of Pond Creek was a wetland area, but in the 1920's, the wetlands were drained in order to allow room for farming and other development. Over time, the watershed has become heavily developed in areas with flat terrain and a wide floodplain. The increase in impervious area in the watershed has also increased runoff times and discharge levels.

The Pond Creek watershed has many major tributaries that flow into Pond Creek, which ultimately flows into the Ohio River. Northern and Southern Ditch are man-made, major conveyance streams with very straight alignments. Wet Woods Creek (formerly Slop Ditch), Roberson Run, Filson Fork, and Mud Creek are also major tributaries that have flood issues associated with them. Other tributaries affected by flooding include Bee Lick Creek, Fern Creek, and Fishpool Creek.

Flood frequency in Pond Creek has been recognized as the worst in the County. Depths for the Flood of 1997 reached over three feet in many areas. Inundation in this watershed caused approximately 80 million dollars in estimated damage during the flood. This represents 40 percent of the damage estimated for the entire county.

As implied by its name, Pond Creek displays rather low flow velocities. For a storm with a 100-year frequency, velocities would range from three to four feet per second on average. A significant portion of Pond Creek soil is a silty clay. Wet Woods Creek, Northern Ditch, and Southern Ditch generally bound this area. This type of soil minimizes the amount of rainfall infiltration into the ground; therefore, more runoff is produced in this area than in areas with more permeable soils.

Beargrass Creek has experienced severe damage from historical floods. The flood of 1937 inundated almost 50% of the watershed. The flood of 1997 caused the Ohio River (outside of the Flood Protection System) to rise as far as Mellwood Avenue for a 3 to 4 day period. Major streams contributing to flow in this watershed are the Muddy, South and Middle Forks of Beargrass Creek as well as the Buechel Branch and the Ohio River.

The Beargrass Creek watershed has a high level of residential and commercial development. This development has created large amounts of impervious area and adversely affected water quality. Structures along the Ohio River run a great risk of flooding because they are outside of the protective floodwall.

Flood depths in Beargrass Creek reach between one and three feet during severe flood events. Flood velocities can reach as high as six to eight feet per second for a 100-year storm.

Floyd's Fork the main streams in this watershed are Floyds Fork, Chenoweth Run, the Long Run tributaries and Pope Lick Creek. Flood effects in Floyds Fork are minimal because large areas have not been developed along streams and other natural corridors. Flood depths are not very severe outside the floodplain. Floyds Fork has steep banks, carries a very large flow, and can produce flood depths of four to six feet or more within its floodplain. Velocities in the Floyds Fork floodplain during a 100-year flood can be severe, up to seven or eight feet per second. Normal flow velocities are in the range of three to five feet per second.

Mill Creek watershed experienced severe flooding near the Ohio River in the 1937, 1964, and 1997 floods. The main streams are the, Upper and Lower Mill Creek, Stephan Ditch, Valley Creek, Blackbird Creek, Lynnview Ditch and Cane Run which all drain into the Ohio River. Much of the flooding in this area is caused by ponding of floodwater near the Ohio River. Many of the other reported flood issues occur from the surcharge of streams in residential and commercial areas. Flood depths for the 1997 flood ranged from 1 to 2 feet. Stream velocities range from 4 to 6 feet per second on average for a 100-year storm. The only area where soil type affects runoff is around Big Run Diversion and Stephan Ditch because this area contains silty clay with limited infiltration potential.

North County The Ohio River floodplain receives the most frequent flooding in Jefferson County. Major streams in this watershed are Goose Creek, Little Goose Creek, Hite Creek, and Harrods Creek. Flood velocities in this watershed are likely between four and seven feet per second for a 100-year flood. Flood depths in the susceptible areas may reach between one and two feet. Ohio River flooding can exceed 20'. Most damage occurs along the unprotected areas along River Road, which suffers annually from 10-year to 25-year flood events.

*Development Constraints***:** The following table from the Floodplain Management Plan presents a summary of the total area of floodplain that exists within the various watershed areas. Based on an analysis of this data, the greatest impacts on development and redevelopment should be occurring and will likely continue within the Pond Creek and Floyds Fork watersheds.

Development Constraints	Area Team Watershed Area (acres)	Area Team Floodplain Area (acres)	Ratio Floodplain / Watershed Area (%)	Ranking w/ Total Floodplain Area
Pond Creek	55,820	10,822	19	1
Floyds Fork	81,733	7,566	9	2
Beargrass	54,433	3,816	7	3
North County	29,113	3,316	11	4
Mill Creek	24,650	447	2	5
Totals	*245,749*	*25,967*	*10*	-

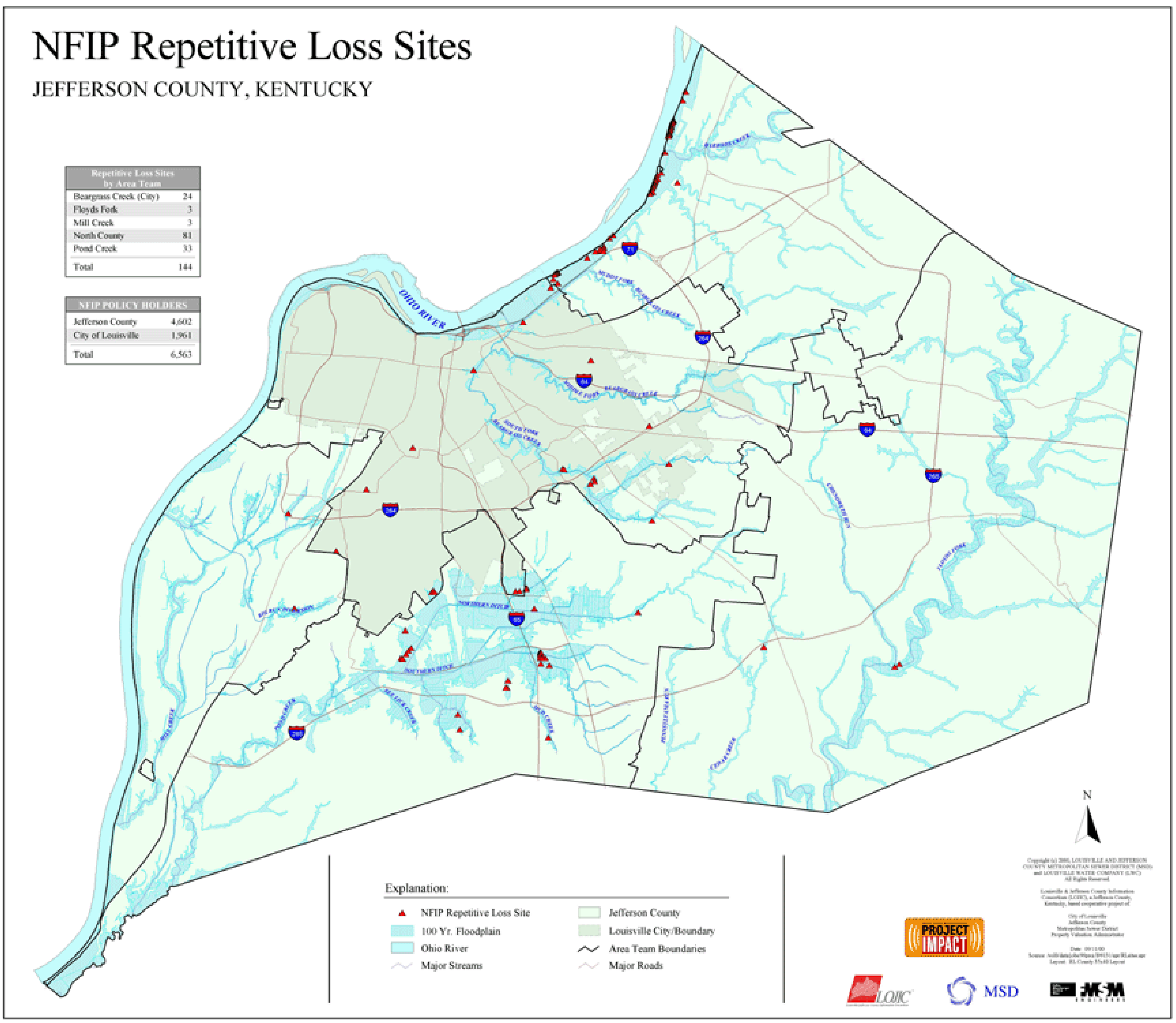
Natural and Beneficial Functions: The following table from the Floodplain Management Plan presents a summary of the total area of wetlands within each of the various watersheds. Wetlands provide a broad array of wildlife habitat and water quality related benefits. The higher the ratio of wetlands to watershed area the better the watershed is at buffering the impacts of urbanization. Based on this table, Pond Creek and Floyds Fork watersheds have the best potential for managing the impacts of urbanization. It is important that the wetlands to watershed ratios be protected and whenever and wherever possible increased.

Natural and Beneficial Functions	Area Team Watershed Area (acres)	Wetlands Area (acres)	Ratio Wetlands / Watershed Area (%)	Ranking w/ Total Wetlands Area
Pond Creek	55,820	1,171	2.10	1
Floyds Fork	81,733	1,048	1.28	2
Mill Creek	24,650	447	1.81	3
North County	29,113	319	1.10	4
Beargrass	54,433	154	0.28	5
Totals	245,749	3,139	1.28	-

Repetitive Loss: As the floodplain administrator, MSD determines Louisville Metro's repetitive loss areas by reviewing the community's official repetitive loss list, provided through FEMA according to flood insurance claims. A property is considered repetitive loss when the structure has experienced more than one flood-related loss and received flood insurance for more than $1,000 in damages within a 10-year period. These areas are designated so that appropriate enforcement, mitigation, and emergency measures are taken.

Louisville Metro has 167 Repetitive Loss Properties according to the 2004 NFIP insurance claims, which is the highest number of repetitive loss properties in Kentucky. Because much of River Road lies outside the protection of the floodwall, it is obviously considered a repetitive loss area. Other areas within the community are also at-risk due to tributaries, ponding and drainage problems.

Following is a map identifying the locations of Louisville's Repetitive Loss areas. Note Louisville' many streams and tributaries. The red markers indicate the location of a repetitive loss property, which shows the surrounding area is potentially at-risk.



Louisville Metro Repetitive Loss Map, LOJIC 2000

Local flood data detail: Following is local flood event information.

- **January 1913:** The New Year in 1913 brought extensive rains to Kentucky and surrounding states causing every major river and stream in Kentucky to flood. Kentucky's total average rainfall for January was 11.41 inches, three times the normal amount. The U.S. Weather Bureau described the lowland areas of the state as being "vast inland seas". The Monthly Weather Review for January of that year collected details of the damage in dollar amounts. For the Louisville district, it reported property damages from the flood at $200,000, a very large sum for 1913. Total crop losses in the Louisville district totaled $50,000.

- **January 1937:** In January of 1937, rains began to fall throughout the Ohio River Valley; eventually triggering what is known today as the "Great Flood of 1937". Overall, total precipitation for January was four times its normal amount in the areas surrounding the river. In fact, there were only eight days in January when the Louisville station recorded no rain. These heavy rains, coupled with an already swollen river, caused a rapid rise in the river's level.

  The morning of January 24 the entire Ohio River was above flood stage. In Louisville, the river rose 6.3 feet from January 21-22. As a result, the river reached nearly 30 feet above flood stage. Louisville, where light and water services had failed, was the hardest hit city along the Ohio River. On January 27, the river reached its crest at 460 feet above sea level or 40 feet above its normal level, which is well over a 100-year event. Almost 70 percent of the city was under water, and 175,000 people were forced to leave their homes. The U.S. Weather Bureau reported that total flood damage for the entire state of Kentucky was $250 million, an incredible sum in 1937. The number of flood-related deaths rose to 190. The flood completely disrupted the life of the community, inundating 60% of the city and 65 square miles in Jefferson County.

- **1964 Flood**: In 1964, the community experienced its third greatest flood of the 20th century. This flood approximated the 100-year base flood. Most of the flood damage occurred in the southwest section of the county with about 1,200 homes being flooded. Property damage was estimated at $3,600,000 (approximately $21 million in 2000 dollars based on Engineering News Record building cost index data).

- **December 1978:** A storm entered the southwest corner of Kentucky and moved northeast producing record-

Floodplain Administrator

Since 1986, the Louisville Jefferson County MSD coordinates Louisville Metro's flood management efforts, with support from FEMA. MSD conducts ongoing flood hazard profiling and modeling, using a watershed-based approach.

Additional information is available at the MSD website at: http://www.msdlouky.org/

breaking rainfall totals for the entire. On December 3, the Louisville Metro area received 2.77 inches of rain. Severe flooding occurred on the Licking, Kentucky, Salt, Green, and Ohio Rivers. Thirty-seven Kentucky counties received a federal disaster declaration due to five lives lost, and property damage at approximately $50 million.

In this flood, recurrence intervals ranged from 50 years to over 200 years. Although the flood on the Ohio River resulted in significant losses to private property, none of the peaks recorded exceeded a 10-year recurrence interval. Flooding concentrated in Louisville and upstream with total damages of approximately $20 million.

- **February 1989:** Precipitation was above normal in Kentucky in the months of December 1988 and January 1989, following an extreme drought during the summer and fall of 1988. By the end of January 1989, minor flooding had occurred on most rivers and streams in Kentucky, setting the stage for major flooding in February 1989. Between February 12-16 rain totals were 8 to 12 inches for an area stretching from Paducah to Lexington. On During February, the Louisville Metro area received 9.02 inches of rain, one of the highest totals on record. The President issued a disaster declaration for 67 counties in Kentucky.

- **May 26 1996:** Several roads across southern Jefferson County were closed due to high waters as 4 inches of rain fell between 11 pm EST May 25 and 11 am EST May 26. Area creeks were already backed up due to the near-flooded Ohio River. Fifty residents of a nursing home on Dixie Highway had to be relocated when a sump pump failure allowed the halls to be filled with water. Property damage estimated at $10.0K.

- **March 1997**: 01 Mar 1997 - 03 Mar 1997: Numerous strong thunderstorms along a stalled out warm front triggered a record 24-hour rainfall for Louisville Metro. On March 1, the Louisville Metro area received 7.22 inches of rain, the highest total on record for one-day. The combination of flooding and/or flash flooding from the record rainfall resulted in an estimated 50,000 homes effected by flooding. Many of these homes had basements entirely flooded with water into the main floor. The Ohio River crested on March 7 in Louisville at about 16 feet above flood stage.

Inland Ponding: The hardest hit areas were in the southwestern section of Jefferson County along the Ohio River. Two other inland areas hit hard were in the Pond Creek watershed south of Louisville and along Floyds Fork in the east. More than 50,000 residences experienced some level of flooding. In addition, high water briefly closed Interstates 64 and 65, as well as scores of secondary roads. The pump station at the mouth of Pond Creek alone moved 2.6 billion gallons of water a day, draining the flood-ravaged neighborhoods of Okolona and Fairdale. During the first few days of the flood, MSD received more than 7,000 calls mostly about sewer backups and surface flooding. MSD estimated that as many as 25,000 customers may not have reported basement backups during the March 1997 flood.

Ohio River Flood: As floodwaters began receding in southern Jefferson County, the flood stage of the river became a threat. A week after the rains, the Ohio River crested in Louisville 15.8 feet above flood stage. Flooding along the Ohio River continued for two weeks throughout Kentucky. The President declared over 87 of the 120 counties in Kentucky federal disaster areas eligible for federal aid statewide.

Damage was estimated at 65 million dollars not including the river flooding on the Ohio River. The southwest floodwall closures passed their first test and protected many areas that flooded in 1964. The Ford factory on Fern Valley Road had damage to up to 1,500 Explorers. 24-hour rainfall totals beginning around February 28 to March 1 ranged from around 6 inches along the Ohio River to 11.5 inches across the communities of Okolona and Fairdale in the southern part of the county. The previous record 24-hour total was 6.97 inches. An estimated 2,500 homes in numerous subdivisions in Okolona and Fairdale and across other parts of the county had to be evacuated with hundreds relocated in temporary shelters. Okolona and Fairdale lie in the Pond Creek floodplain, which was formerly swampland. National Guard had to get many of these people out by boat or dump trucks. Thousands of cars were evacuated or stalled out due to the high waters. Numerous rescues were made with people trapped in cars and in houses. Bloated storm sewers popped off manhole covers that left cars quickly inundated in advancing high water. Several roads were closed around the Jefferson County Memorial Forest due to mudslides. A 16-year-old boy was killed near Jeffersontown as his van was swept off the road by the swollen Chenoweth Creek. Numerous roads including parts of Interstate 65 and 64 were closed through the morning of March 2. Because of all the damage, the County-Judge Executive declared the county a state of emergency.

In Kentucky, twenty-one people were killed and an estimated $250 to $500 million in damages where caused by the flooding. The damages incurred by the entire Ohio River flood exceeded $1 billion and over 67 deaths. Fortunately, floodwalls partially protected Louisville, preventing even more damage.

Hailstorm Profile

SUMMARY OF HAILSTORM RISK FACTORS	
Period of occurrence:	Year-round
Number of Events to-date: 1961 - 06/30/2004	59+
Probability of event(s):	Likely, usually associated with severe thunderstorms.
Warning time:	Minutes to hours
Potential Impact(s):	Large hailstorms can include minimal to severe property and crop damage and destruction.
Cause injury or death	Injury
Potential Facility Shutdown	Days

In Kentucky

According to the NOAA, 1,972 reported hailstorms have happened in Kentucky since 1980. These storms of varying sized hail have caused $1.3 billion worth of property damage and $5.4 million worth of crop damage.

Historical Impact: The effects of large hailstorms can include minimal to severe property and crop damage and destruction. Most thunderstorms do not produce hail, and ones that do normally produce only small hailstones not more than one-half inch in diameter.

Potential Impacts of Hail: Large hailstorms can include minimal to severe property and crop damage and destruction. The combination of gravity and a downward wind known as a downburst (a common occurrence during severe thunderstorms) can propel a hailstone at speeds upwards of 90 mph. At such excessive speeds, large hailstones have been known to penetrate straight through roof coverings and the deck to which they are attached. Although the majority of hailstorms are not quite so severe, even moderate hailstorms can damage buildings, automobiles, crops, and other personal property.

The following event detail information is typical of damage and injury due to hailstorms. The NCDC's website archives lists 59 hail events occurring during 1961 – 2004.

- **20 Apr 1996, Thunderstorm Wind/hail:** A garage was destroyed, a roof damaged, and 1-inch hail was reported on Dale Lane in Fisherville. Magnitude reported at 50 and Property Damage estimated at $3.0K.

- **03 May 1996, Hail:** Hail from golf ball to baseball size totaled numerous cars across various parts of Louisville including Churchill Downs, the International Airport, Highview, Fern Creek, Okolona, Jeffersontown, Camp Taylor, and Hikes Point. Three rental-car lots near the International

Airport were totaled. Baseball size hail at Jeffersontown, Fern Creek, Highview, and Camp Taylor accumulated to 8 inches. Accumulations were also substantial along the Gene Snyder Freeway just south of Fern Creek. The hail shift was approximately 5 miles wide and went all the way through the county. Several insurance companies have had over 100 hundred claims due to car and home damage. Most of the home damage was to shingles, siding and windows. Magnitude measured at 2.75 inches. Property Damage estimated at $20.0M.

- **11 May 2001:** Several cars were damaged by hail near Valley Station. Magnitude measured at 1.75 inches and Property Damage estimated at $5.0K.

Karst/Sinkhole Profile

SUMMARY OF KARST/SINKHOLE RISK FACTORS

Period of occurrence:	At any time
Number of Events to-date	Unknown
Probability of event(s):	Infrequent
Warning time:	Weeks to months, according to monitoring or maintenance.
Potential Impact(s):	Economic losses such as decreased land values and Agro-business losses. May cause minimal to severe property damage and destruction. May cause geological movement, causing infrastructure damages.
Cause injury or death	Injury
Potential Facility Shutdown	Days to weeks

In Kentucky

About 38% of the state has sinkholes that are recognizable on topographic maps, and 25% has obvious and well-developed Karst features. Much of the state's beautiful scenery is a direct result of the development of a Karst landscape.

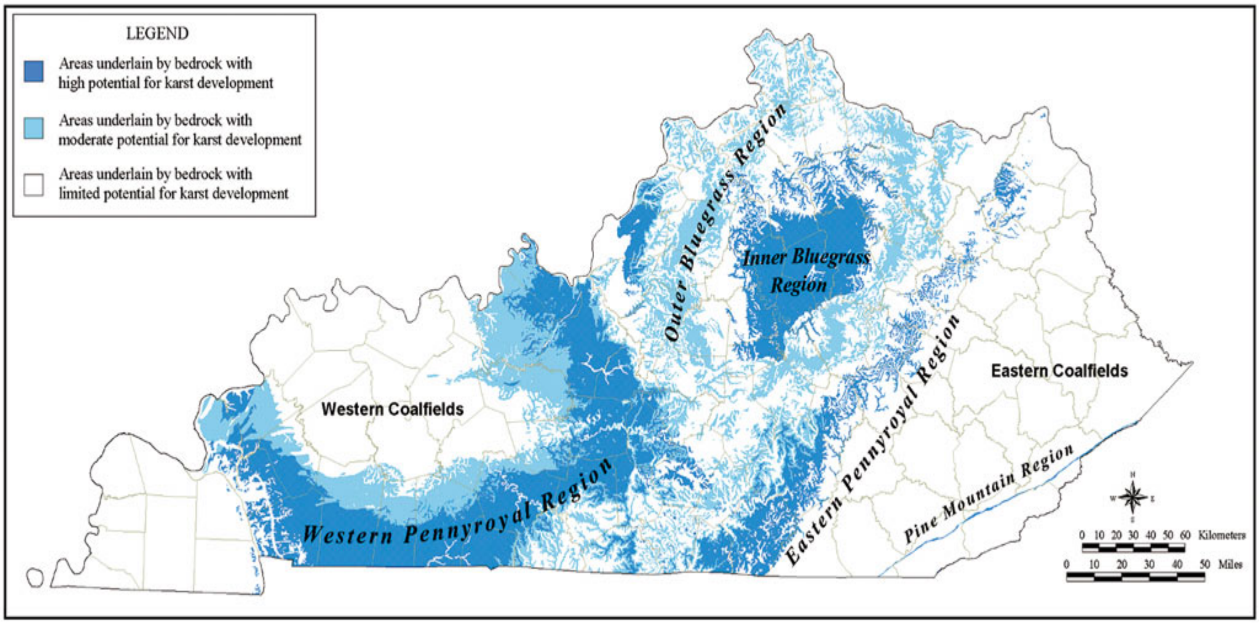
Background: Karst landscapes and aquifers form when water dissolves limestone, gypsum, and other rocks. The surface expression of Karst includes sinkholes, sinking streams and springs. Karst hazards include: sinkhole flooding, sudden cover collapse, leakage around dams, and collapse of lagoons resulting in waste spills and radon infiltration into homes. Sinkholes are among the most common problems of living in a karst area.

Historical Impact: Kentucky contains one of the world's largest Karst-ridden topographies. Springs and wells in Karst areas supply water to tens of thousands of homes. Much of Kentucky's prime farmland is underlain by Karst, as is a substantial amount of the Daniel Boone National Forest with its important recreational and timber resources.

Caves are also important Karst features, providing recreation and unique ecosystems. Mammoth Cave is the longest surveyed cave in the world, with more than 350 miles of passages. Two other caves in the state stretch more than 30 miles, and nine Kentucky caves are among the 50 longest caves in the U.S.

The most noticeable hazards in Kentucky are sinkhole flooding and cover collapse. Soil collapses are common in karst terrain, where water drains to caves through fissures in the bedrock. Over time, domes of soil form over these fissures and new development increases the drainage into these fissures, forming a sinkhole. Unfortunately, collapses are seldom reported to any central agency.

See the following map of karst areas in Kentucky.

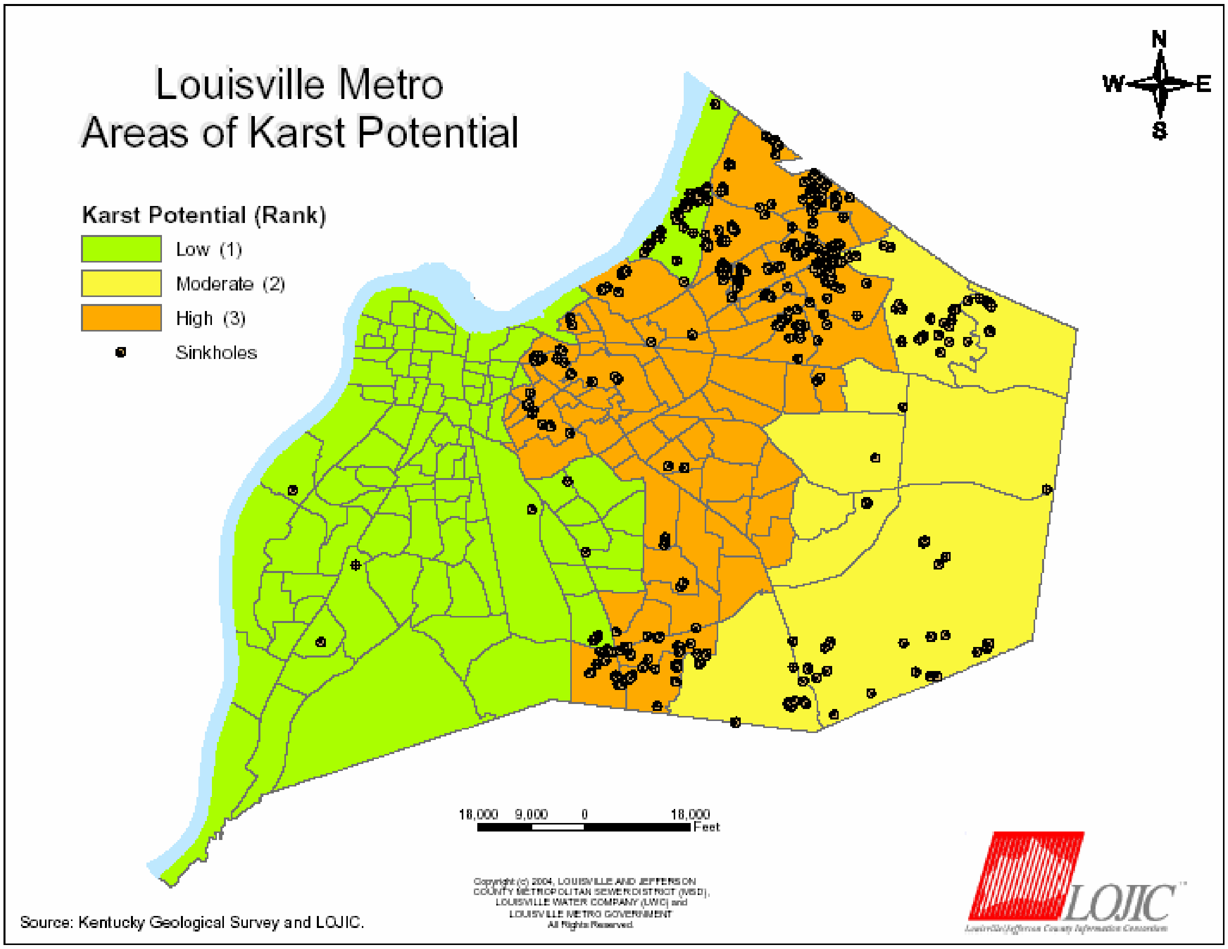


(Source: www.esri.com/news/arcnews/winter0203articles/winter0203gifs/p31p1-1g.jpg)

Karst Potential Impact in Louisville: Damage to infrastructure from sinkhole flooding and cover collapse is so common in Kentucky that it is typically dealt with by local authorities as a routine matter. Throughout the state, many reservoirs of all sizes have leaking dams or leakage through carbonate bedrock around the dam. Louisville Metro is vulnerable to karst and sinkhole flooding. Following is a map of the sinkholes and karst areas in Louisville Metro.

Strategies to Avoid Sinkhole Collapse

- Karst areas should be mapped thoroughly to help identify buried sinkholes and fracture trends. Geophysical methods, aerial photography, and digitally enhanced multi-spectral scanning can identify hidden soil drainage patterns, stressed vegetation, and moisture anomalies in soils over sinkholes.
- In large sinkholes, use bridges, pilings, pads of rock, concrete, special textiles, paved ditches, curbs, grouting, flumes, overflow channels, or a combination of methods to provide support for roads and other structures.
- Large buildings should not be built above domes in caves.



Karst Map, LOJIC 2005

Landslide Profile

SUMMARY OF LANDSLIDE RISK FACTORS

Period of occurrence:	At any time. Chance of occurrence increases after heavy rainfall, snowmelt, or construction activity.
Number of Events to-date: 1990 - 2003	4 +
Probability of event(s):	Infrequent. . More likely in SW portion of county where areas prone to landslide. Probability increases at the base of steep slope; the base of drainage channel; and developed hillsides where leach-field septic systems are used.
Warning time:	Weeks to months, depends on inspection for weaknesses in rock and soil. Some landslides move slowly and cause damage gradually, whereas others move so rapidly that they can destroy property and take lives suddenly and unexpectedly.
Potential Impact(s):	Economic losses such as decreased land values, Agro-business losses, disruption of utility and transportation systems, and costs for any litigation. May cause geological movement, causing infrastructure damages ranging from minimal to severe.
Cause injury or death	Injury
Potential Facility Shutdown	Days to weeks

Background: Gravity is the force driving landslide movement. Factors that allow the force of gravity to overcome the resistance of earth material to landslide movement include: saturation by water, steepening of slopes by erosion or construction, alternate freezing or thawing, and earthquake shaking.

Slope failures are major natural hazards in many areas throughout the world. Slope failures are also referred to as *mass movements.* A slope failure is classified based on how it moves and the type of material being moved.

Five major types of slope failures have been identified: ***Creep****:* very slow movement of rock or soil downslope. ***Falls****:* very rapid fall of rock and earth material from vertical or near vertical slopes. ***Flows****:* slow to rapid movement of rock, soil, snow, or ice. Types of flows include mudflows, earthflows, debris flows, and snow avalanches. ***Slides****:* Very slow to very rapid movement of soil or rock. This category includes rockslides, earth slides, and slumps. ***Subsidence****:* slow to very rapid collapse of rock or soil into underlying spaces. Sinkholes in karst landscapes are a common example.

In many locations, both geologic and atmospheric processes may play a role in the movement of a slope. Slope failures can occur in any season, but are more likely to be triggered by weather events such as rain, snow, or freezing and thawing of soil water. With the exception of slope failures triggered by geologic processes, most slope failures in North America occur between spring and fall.

- In early spring, snowmelt can increase pore pressures in the soil, increasing the risk of slope failures.
- During summer and fall, intense or prolonged rainfall can trigger slope failures.
- Freeze-thaw events, which usually happen during spring and fall but also during warm winters, can increase the potential for slope failure.

Landslide Potential Impact in Louisville Metro: Landslides are more likely to occur in the SW portion of the county where areas are prone to landslide. Probability increases at the base of steep slope; the base of drainage channel; and developed hillsides where leach-field septic systems are used. Several studies have shown that almost any modification of a slope by people increases the risk of slope movement, especially in areas already susceptible.

Landslide problems are usually related to certain rock formations that yield soils that are unstable on moderate to steep slopes. Often, slopes are cut into or oversteeped to create additional level land for development. Individuals can take steps to reduce their personal risk.

- Steep slopes are more susceptible to landslides and should be avoided when choosing a building site.
- Slope stability decreases as water moves into the soil. Springs, seeps, roof runoff, gutter down spouts, septic systems, and site grading that cause ponding or runoff are sources of water that often contribute to landslides.
- Changing the natural slope by creating a level area where none previously existed adds weight and increases the chance of a landslide.
- Poor site selection for roads and driveways.

- Improper placement of fill material.
- Removal of trees and other vegetation. Plants, especially trees, help remove water and stabilize the soil with their extensive root systems.

Public and private economic losses from landslides include not only the direct costs of replacing and repairing damaged facilities, but also the indirect cost associated with lost productivity, disruption of utility and transportation systems, reduced property values, and costs for any litigation. Some indirect costs are difficult to evaluate, thus estimates are usually conservative or simply ignored. If indirect costs were realistically determined, they likely would exceed direct costs.

Much of the economic loss is borne by Federal, State, and local agencies responsible for disaster assistance, and highway maintenance and repair. Flood insurance does not cover landslides. Private costs involve mainly damage to land and structures. A severe landslide can result in financial ruin for the property owners because landslide insurance (except for debris flow coverage) or other means of spreading the costs of damage are unavailable.

Louisville Metro Landslide History: No reports are available from USGS, NWS, NCDC, or the State Mitigation Plan for landslide incidences. However, Louisville Metro has experienced Landsliding and Slope Failure affecting roads and infrastructure items. During the planning process, community members and community officials identified slope failure areas that have repeat occurrences.

Unstable soils also contribute to landslide potential in Louisville Metro as shown on "Core Graphic 4" of the *Louisville and Jefferson County Comprehensive Plan*: Soil types that are subject to mass wasting such as creep, slump or even landslides and mudslides coincide with slopes over 6 percent and the presence of underlying shale bedrock. Listed below are the soil types that are considered unstable due to the presence of underlying shale. Any highly sloped area may be subject to unstable conditions regardless of the presence of underlying shale.

Louisville Metro Soil Types:

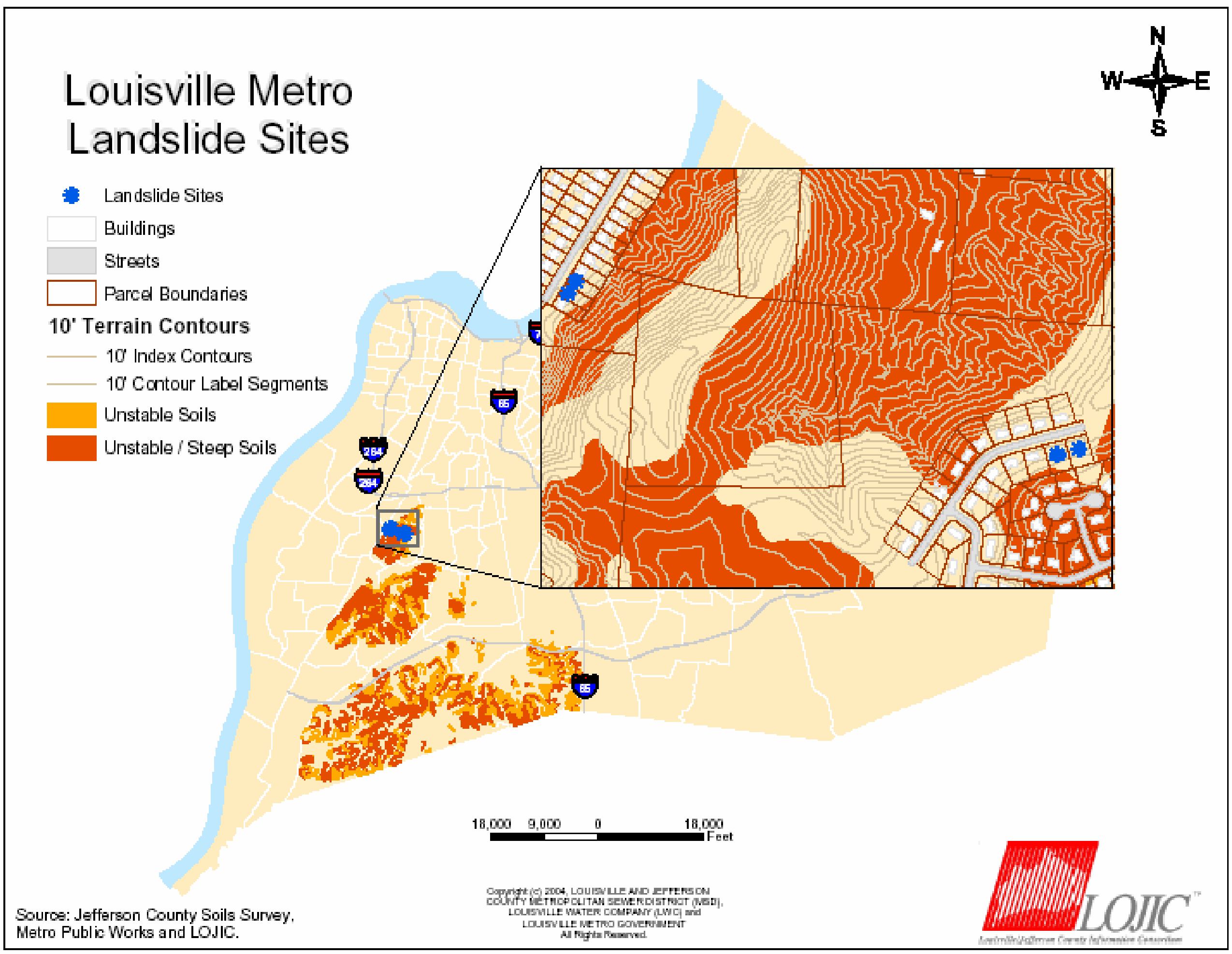
HgD	Holston gravelly silt loam, 12 to 20 percent slopes
HgE	Holston gravelly silt loam, 20 to 30 percent slopes
MpD2	Memphis silt loam, 12 to 20 percent slopes, eroded
MpE2	Memphis silt loam, 20 to 30 percent slopes, eroded
RcE	Rockcastle silt loam, 15 to 30 percent slopes
ZaC2	Zanesville silt loam, 6 to 12 percent slopes, eroded
ZaD2	Zanesville silt loam, 12 to 20 percent slopes, eroded

Source: Soil Survey: Jefferson County, Kentucky, US Department of Agriculture Soil Conservation Service (June 1966)

The following unofficial reports of landslides are located in the vulnerable area of SW Louisville Metro (see map on next page).

- Louisville Metro Public Works reports two properties along Pine Mountain Road were acquired due to landslides; with estimated loses at around $150,000 each or $300,000 total.
- Public Works reports several properties (~60) along Cardinal Hill show signs of under-pinning.
- EMA reports, after the severe storm of 2003, 2 properties experienced minor to major landslide damage.
- Reports of landslides in Iroquois park, around Mitchell Hill, are commonly known for eroding.

Following is a map of the areas vulnerable to landslide in Louisville Metro. The inset shows areas in the southwest portion of the area where landslides have occurred.



Landslide Map, LOJIC 2005

Severe Storm Profile

SUMMARY OF SEVERE STORMS RISK FACTORS

Period of occurrence:	Spring, Summer and Fall
Number of Events to-date: 1950 - 09/30/2004	Thunderstorms NCDC: 176 Lightning NCDC: 8
Probability of event(s):	Frequent
Warning time:	Minutes to hours
Potential Impact(s):	Utility damage and outages, infrastructure damage (transportation and communication systems), structural damage, fire, damaged or destroyed critical facilities, and hazardous material releases. Impacts human life, health, and public safety.
Cause injury or death	Injury and risk of multiple deaths
Potential Facility Shutdown	Days to weeks

Background: The Midwest and Great Plains regions of the U.S. average between 40 and 60 days of thunderstorms per year. These two regions are prone to some of the most severe thunderstorms on Earth.

In Kentucky

In Kentucky, during 1996 and 2003, there were eleven Presidential Declarations due to severe storms and other storm-related events.

Potential Impacts of Severe Storms: Due to the destructive nature of thunderstorms and lightning these events impact human life, health, and public safety. The community is at-risk for: utility damage and outages, infrastructure damage (transportation and communication systems), structural damage, fire, damaged or destroyed critical facilities, and hazardous material releases.

Louisville Metro Severe Storm History: Louisville Metro has received three presidential declarations for severe storms, as shown in the following table.

DR #	Declaration Date	Disaster Type	# of KY Declared Counties
568	12/12/1978	Severe Storms, Flooding	37
821	2/24/1989	Severe Storms, Flooding	67
1471	6/3/2003	Landslide, Severe Storm, Tornado, Flooding	44

Historical Impact: The NCDC's website archives table shows 176 thunderstorm events occurring during 1957 – 2004. The following narratives are typical of severe storms and provide detailed information on 11 severe storms that resulted in a death, injury, or property damage over $50K.

A thunderstorm is considered severe when it produces winds of 58 mph or greater, hail of an inch or greater, or a tornado.

- **15 April 1993:** Trees blown over in the SE portion of the county, causing $50.0K in Property Damage.

- **14 November 1993:** Numerous trees and power lines were blown down in Prospect. The front of a children's clothing store was blown off causing $50.0K in Property Damage.

- **14 May 1994:** A severe weather spotter reported an overturned trailer and uprooted trees 5 to 10 miles East of Louisville. In the same area, a WHAS-TV meteorologist relayed a report of a twisted off sign being blown through a window of a Sizzler restaurant. Three people were injured and $500.K in Property Damage.

- **05 May 1996:** Fallen trees heavily damaged ten homes in Fairdale. Trees were also reported down throughout Jefferson County as the line of the thunderstorms moved through. HAM radio operators received reports of 70 to 80 mph wind gusts. $100.0K reported in Property Damage.

- **10 May 1996:** Winds of Magnitude 50 knocked down numerous trees across Louisville. Hardest hit was Middletown where five homes were seriously damaged. One home was damaged beyond repair Middletown; Property Damage at $200.0K.

- **10 November 1998**: In Louisville, one woman was killed and two injured when a mature tree fell on top of a sport utility vehicle. Across much of the area, trees and power lines were downed by winds, with over 20,000 people without power during the event in Jefferson and neighboring counties. One fatality, and $42.0K in Property Damage.

- **20 April 2000:** An elderly woman was killed when a tree was blown on to a mobile home at the Pioneer Mobile Home Park. Wind Magnitude 70. One fatality, and $15.0K in Property Damage.

- **08 July 2001:** A section of steel roof was peeled off a hangar at the Louisville International Airport. There was some property damage as trees were blown on to vehicles. Wind magnitude 80, and $75.0K in Property Damage.

- **20 April 2003:** A tree was blown onto a house near St. Andrews Church Rd. Another tree was struck by lightning and fell onto a house. A minor house fire occurred when trees were blown onto power lines. Numerous trees and power lines were downed, and up to 27,000 residents were without power. Wind Magnitude 65 and $75.0K in Property Damage.

- **02 August 2003:** Harrods Creek: numerous trees and power lines were downed. Three vehicles were destroyed when trees were blown onto them. Thirteen thousand Jefferson County customers were without power. Wind magnitude 60, and $75.0K in Property Damage.

- **30 May 2004:** At 34th and Rudd Streets, there was shingle and chimney damage to houses and extensive damage to trees and power lines. Wind magnitude 70, and $50.0K in Property Damage. Also, in Fairdale, at the Autumn Lake Mobile Home Park, around six mobile homes received extensive damage and numerous trees were downed. A man was taken to the hospital with a back injury. One injury, wind magnitude 70, and $150.0K in Property Damage.

Lightning Profile

Local data and NCDC website archives show eight lightning events. Following is a description of sample lightning events that caused injury or property damage.

- **22 July 1995:** A man was slightly injured when lightning struck a utility pole and traveled through the phone lines into his living room.

- **07 August 1995:** Lightning stuck two houses destroying one and damaging another; property damage was estimated at $100.0K.

- **26 May 1996:** Lightning caused a fire that damaged the basement and some of the first floor walls of a brick two-story house. Property Damage was estimated at $2.0K. Lightning struck a house heavily damaging the second floor. Property Damage was estimated at $10.0K.

- **07 July 1996:** Lightning hit a condominium complex and damaged three units in Middletown. Property Damage was estimated at $10.0K.

- **25 May 2004:** A house fire started due to a lightning strike in the 6700 block of Green Manor Drive in Highview. Property Damage was estimated at $10.0K. Lightning blew a three-foot hole in the side of a house in Lyndon and a fire caused moderate damage to the second floor and attic. Property Damage was estimated at $20.0K.
- **27 May 2004:** A tree was struck by lightning and fell on a car, destroying it. Property Damage was estimated at $10.0K.

Severe Winter Storm Profile

SUMMARY OF SEVERE WINTER STORMS RISK FACTORS

Period of occurrence:	Winter
Number of Events to-date: 1976 - 09/30/2004	12
Probability of event(s):	Likely
Warning time:	Days for snow Minutes to hours for ice.
Potential Impact(s):	Utility damage and outages, infrastructure damage (transportation and communication systems), structural damage, and damaged or destroyed critical facilities Can cause severe transportation problems and make travel extremely dangerous. Power outages, which results in loss of electrical power and potentially loss of heat, and human life. Extreme cold temperatures may lead to frozen water mains and pipes, damaged car engines, and prolonged exposure to cold resulting in frostbite.
Cause injury or death	Injury and slight risk of death. Significant threat to the elderly.
Potential Facility Shutdown	Days

Background: Kentucky's location makes it vulnerable to heavy snowfall due to the state's proximity to the Gulf of Mexico, which provides a necessary moisture source, yet it is far enough north to be influenced by polar air masses. Low-pressure systems that bring heavy snow to Kentucky usually track eastward across the southern U.S. before turning toward the northeast. Frequently, these systems move up the east coast and have little effect on Kentucky. Sometimes, however, storms turn and move along the western margin of the Appalachian Mountains. With cold air in place over Kentucky, these storms bring moisture from the Gulf of Mexico and can dump heavy snow.

In Kentucky

According to NOAA data, 132 winter storms have affected the state of Kentucky since 1993. These storms have caused $43.3 million in property damage, injured 5, and caused 12 deaths.

Potential Impact to Louisville Metro: Due to the destructive nature of snow and ice these events impact human life, health, and public safety. Community-wide impacts include: power outages, which results in loss of electrical power and potentially loss of heat, and human life. Extreme cold temperatures may lead to frozen water mains and pipes, damaged car engines, and prolonged exposure to cold resulting in frostbite. Community-wide impacts include: Utility damage and outages, infrastructure damage (transportation and communication systems), structural damage, and damaged or destroyed critical facilities. Can cause severe transportation problems and make travel extremely dangerous.

The level of impact severe winter weather will have upon a community greatly depends on its ability to manage and control its effects, such as the rapid mobilization of snow removal equipment. Louisville Metro has experienced several crippling winter storms over the years, which is common to the region due to its geographical location. It is expensive to acquire and maintain the necessary resources to combat winter's effects such as generators, snow removal equipment, and trucks. Preparedness includes, planning for emergency shelters and power outages.

Historical Impact: Following is a table showing the only Presidentially declared snow event in Louisville Metro.

Louisville Metro Presidentially Declared Snow/Ice event

DR #	Declaration Date	Disaster Type	# of KY Declared Counties
1089	1/13/1996	Blizzard	120

(Source: FEMA)

According to the NWS, the following snowfall totals are normal for the Louisville area.

NCDC Snowfall Summary
Station: 154954 LOUISVILLE WSO AIRPORT, KY
1971 - 2000 Averages

Element	JAN	FEB	MAR	APR	OCT	NOV	DEC	ANNUAL
Snow (in)	5.1	4.5	2.1	0.2	0.1	0.6	2.0	14.6

Louisville Metro Historic Snow Events:

In Louisville Metro, severe winter weather conditions normally occur during the months of January and February. The Louisville Metro EOP lists the following years as the most recent severe winters: 1976, 1977, 1978, 1979, 1994, and 1998. Following is event detail for some of Louisville Metro's snow winter storm events.

- **January 1994**: Known locally as the perfect storm, which caused 16 inch-blanket of snow. Snow came atop a downpour of rain that froze, forming a glassy smooth layer of ice under the snow. Frigid temperatures that plunged to a record 22 degrees below cemented it all in place. About 20,000 residents lost electrical power and at last three people died from exposure. The storm paralyzed businesses such as UPS and the hub operations as well as Ford Motor Co, which were forced to close down. Commerce also was restricted because Interstate highways were closed for two days, and government for four days. It took Louisville five days to dig out.

  - **January 1996:** A major snowstorm hit Kentucky on January 6-7. The notorious "Blizzard of 96'" brought a significant amount of snowfall to the Greater Cincinnati/Northern Kentucky airport, and was the largest 24-hour snowfall on record. Total snowfall from the storm at the airport was 14.3 inches, while in a typical entire season this location normally receives 23 inches of snowfall.

Blizzards

Snow does not have to be falling during a blizzard. Winds need to be 35mph or greater for at least 3 hours to be officially called a blizzard.

  - **March 1996:** A deep low-pressure system moved across Kentucky drawing in large amounts of moisture from the Gulf of Mexico. Heavy snow was reported across mainly west central Kentucky from March 19 to March 20. Many areas lost power due to the heavy wet snow. The Governor declared a state of emergency for 22 counties across west central Kentucky. The state ordered 185 National Guard troops into the worst areas to help police, doctors, and road crews. As many as 37,100 customers were without power.

  - **February 1998:** A freak winter storm dumped as much as 25 inches of snow on parts of Kentucky from February 3 to February 6. The storm system took a typical wintertime path from the Gulf Coast and northeast along the Atlantic coast. However, due to the strength of the system and its slow movement, enough deep layered moisture was pulled into the system from the Atlantic Ocean, that the moisture was able to negotiate the Appalachian Mountains bringing heavy snows much further west than typical "nor'easters". Most Kentucky counties were declared states of emergency by the morning of February 5 as trees and power lines were down across a large area of the Louisville Warning Area and roads became snow covered, slick, hazardous and in some remote places impassable. Over the three days, three people were killed and four injured across Louisville. One four-year-old boy was killed and four injured in a multi-car pileup on Interstate 65 in Louisville. A 71-year-

old man was run crushed by his own truck as he and another man tried to free it from a snowdrift. A 35-year-old man was killed in a traffic accident in Taylorsville. By February 4, an area of 10 plus inch accumulations totals stretched all the way to the Ohio River. Louisville had an all-time storm total snowfall of 22.4 inches eclipsing the old record (15.9 inches on January 16-17, 1994) by 6.5 inches. Fatalities: 3. Injuries: 4. Property Damage estimated at $180.0K.

- **December 2000:** The Midwestern region of the U. S. experienced its second coldest December in the 106-year record of observations. The average temperature was 14.3°F, just missing the 1983 record of 13.9°F. At least 15 first-order stations broke all-time records for December snowfall, including Louisville. The NWS reports that in 2000, winter storms caused approximately $1 billion of damage in the U. S.

- **February 2003:** Freezing rain began on the 15th and changed to sleet by evening, through most of the 16th. A thick coating of mostly sleet and some freezing rain accumulated one to two inches in most locations. Most of the property damage assessment in the area was due to expenses associated with the restoration of power and post storm cleanup of tree damage at $180.0K. Sections of Interstate 64 were periodically shut down during the storm.

Tornado Profile

SUMMARY OF TORNADO RISK FACTORS

Period of occurrence:	Year-round, primarily during March through August
Number of Events to-date: 1964 – 9/30/2004	9
Probability of event(s):	Infrequent
Warning time:	Minutes to hours. Over 80 % of all tornadoes strike between noon and midnight.
Potential Impact(s):	Utility damage and outages, infrastructure damage (transportation and communication systems), structural damage, and damaged or destroyed critical facilities. Impacts human life, health, and public safety.
Cause injury or death	Injury and risk of multiple deaths
Potential facilities shutdown?	30 days or more

Background: Kentucky is located in the most severe wind zone (ZONE IV 250 mph) in the country. This signifies that most of the state is highly vulnerable to tornadic weather. Tornadoes are somewhat common throughout Kentucky and have occurred in every month of the year. Conversely, the occurrence of a tornado is highly unpredictable in it is impossible to forecast the exact time and location that it will touch down and the path that it will take

Most tornadoes occur between March and July, with the month of May normally experiencing the greatest number of tornadoes. The strongest tornadoes, which usually result in the highest number of deaths and greatest destruction of property, occur between April and June. Most deaths occur in April, which is considered the beginning of the tornado season.

In Kentucky

The occurrence of a Kentucky tornado is predictable because a tornado touches down somewhere in the Commonwealth every year. Tornadoes have caused $707.7 million in property damage, $186,000 in crop damage, 115 deaths, and 2,593 injuries.

According to NOAA, 661 tornadoes have been reported since 1950, an average of about 12 per year.

- 3 in the F5 class,
- 37 in the F4 class,
- 82 in the F3 class

Tornado Potential Impact: Due to the destructive nature of tornadoes and wind, these events impact human life, health, and public safety. Community-wide impacts include: utility damage and outages, infrastructure damage (transportation and communication systems), structural damage, and damaged

or destroyed critical facilities. Tornadoes can also cause severe transportation problems and make travel extremely dangerous.
Historical Impact: Following is a table showing the number of tornadoes from 1950 – 2003 in Kentucky.

Breakdown of Kentucky Tornadoes by Class 1950-2003	
Fujita Class	Tornadoes
F0	125
F1	237
F2	158
F3	82
F4	37
F5	3
N/A	23
TOTAL	665

Louisville Metro Tornado History: One tornado event has been Presidentially declared for Louisville Metro, as shown in this table.

DR #	Declaration Date	Disaster Type	Deaths	Injuries	Total Declared Counties in Kentucky
420	4/4/1974	Tornado	3	226	34

Following are descriptions of the major tornadoes in Louisville Metro and shows the level of typical historical damage.

- **March 25 1964:** March 25, 1964, two tornadoes touched down in a 15-minute span. **19:00 pm:** Length 10 miles, width 33 yards, Magnitude F2, 1 injury, and $250.0K in Property Damage.
  • **19:15 pm**: Length 5 miles, width 33 yards, Magnitude F2, and $250.0K in Property Damage.

- **01 April 1970:** Length 2 miles, width 33 yards, Magnitude F1, and $25.0K in Property Damage.

- **03 April 1974:** On April 4, 1974, an F5 tornado with a length of 10 miles and a width of 440 yards ripped through Jefferson/Meade County. The 1974 tornado was among about 20 in Kentucky and 148 that struck from Alabama to Michigan that day and became know as the “Super Outbreak”. In Kentucky, there were 1,377 injuries and $110 million in damages in 39 counties.

Forecasters failed to predict just how violent the weather would be and could not provide enough warning about where the funnels would begin dropping from thunderstorms. The tornado crossed Interstate-65 at the Kentucky Fair & Exposition Center, blew the horse barns down, and tore open the roofs of Freedom Hall and the East Wing. In Cherokee Park, the twisters uprooted about 80% of nearly 2,000 hardwood trees, and experts estimated 10,000 were lost in 90 seconds. The tornadoes caused 257 injuries, and numerous deaths in Louisville.

Three decades after the 1974 tornadoes, a similar swarm of tornadoes probably would cause fewer deaths because of dramatic innovations in weather forecasting and warning tools, spawned in part by the 1974 tornadoes.

- **29 May 1974:** Magnitude F1, and $25.0K in Property Damage.

- **30 June 1977:** Length 2 miles, width 100 yards, Magnitude F0, 1 injury, and $25.0K in Property Damage.

- **28 May 1996:** The supercell that crossed the Ohio River from Harrison County produced the second most destructive tornado in history. A second tornado formed 4 miles northwest of Brooks in south central Jefferson County. The tornado was initially estimated at F0-F1 intensity and moved east-southeast and quickly strengthened as it moved into north central Bullitt County near Holsclaw Hill road and Top Hill road where numerous trees were snapped off and some tree bark was stripped. The tornado crossed near the Brooks exit at interstate 65 turning over five tractor-trailers and damaging a Comfort Inn, Arby's, and a Cracker Barrel. Widespread severe structural damage occurred to over 1000 homes in these towns and ten people required hospital care. The tornado was rated a strong F3 in Pioneer Village and Hillview, where winds were estimated at around 200 mph. Eyewitnesses, the NWS survey, as well as video footage revealed multiple-vortices within the parent tornado. This multiple-vortex tornado appeared to consolidate into one funnel as it moved through the Northfield subdivision near Mount Washington and was categorized as an F3. The tornado then moved into Spencer County 3 miles west of Mount Washington. The total path length across the three counties was estimated at 30 miles.

- **04 October 2002:** A riverboat captain spotted a waterspout on the Ohio River near Louisville moving inland over eastern Jefferson County, touching down intermittently. It knocked down trees and blew the roofs off several homes in the Springhurst area in NE potion of the county. The backside of the clubhouse at the Indian Springs Country Club was blown out. Thunderstorm winds downed trees over parts of eastern Jefferson County near the path of the tornado. Length 6 miles, width 50 yards, Magnitude F1, and $150.0K in Property Damage.

- **30 May 2004:** A weak tornado touched down just east of Bardstown Road near the entrance to the Glenmary subdivision. Significant large tree damage occurred. Roofs showed minor structural damage, but most damage was due to structures being hit by falling trees. The tornado lifted just east of the subdivision, and a funnel cloud was reported near the Gene Snyder Freeway and Billtown Road. The width 30 yards, Magnitude at F0, 1 injury, and $100.0K in Property Damage.

Wildfire Profile

SUMMARY OF WILDFIRE RISK FACTORS

Period of occurrence:	Year-Round, primarily Summer
Number of Events to-date	Unknown
Probability of event(s):	Infrequent. Chances of occurrence increase with drought or earthquake.
Warning time:	None, unless related to drought. Humans, through negligence, accident, or intentional arson, have caused approximately 90% of all wildfires in the last decade.
Potential Impact(s):	Impacts human life, health, and public safety. Loss of wildlife habitat, increased soil erosion, and degraded water quality. Utility damage and outages, infrastructure damage (transportation and communication systems), structural damage, damaged or destroyed critical facilities, and hazardous material releases.
Cause injury or death	Injury and risk of death
Potential facilities shutdown?	30 days or more

In Kentucky

Of Kentucky's 25,288,300 acres of land area, over half (12,700,000 acres) is forested. Another 22% of the land is cropland while 18% is pastureland. Through the abandonment of marginal forestland, contrary to popular belief, Kentucky has continued to gain forestland.

Background: Since 1977, Kentucky has experienced 2,033 reported wildfires and 78,710 acres burned. Approximately 86% of these fires were caused by humans; and of those approximately 50% were arson. The damage to Kentucky's timber resource is valued at $85.58 per acre: an average yearly loss of $6,736,001. This figure does not account for the loss of wildlife habitat, increased soil erosion, and degraded water quality.

Wildfire Potential Impact: Impacts human life, health, and public safety. Loss of wildlife habitat, increased soil erosion, and degraded water quality. Utility damage and outages, infrastructure damage (transportation and communication systems), structural damage, damaged or destroyed critical facilities, and hazardous material releases.

Wildfire is listed in the Louisville Metro EOP and the potential for wild or grass fire is apparent. However, local records of fire are limited. Project Staff determined the best way to determine wildfire potential, until better data is gathered, is to target at-risk areas in the area. Therefore, it was determined 3-acre increments of tree cover would show the most vulnerable area in Louisville Metro. A Wildfire Vulnerability Map of vulnerable 3-acre tree stands is located in Section 3.3.3.

Historical Impact: While all but seven of the state's counties have reported fires of some magnitude in the last several years, fire most threatens the eastern part of Kentucky because of the extensively forested areas in the region and the poor accessibility of many areas which makes fire suppression more difficult. Arson was responsible for more than half of the wildfires occurring on private woodlands during the past 10 years; debris burning 28%; and carelessness from smoking at 3% (see table below).

Causes of Kentucky Wildfires 1993-2002		
Cause	Number of Fires	Percent of Fires
Arson	8233	55
Campfire	199	1
Children	288	2
Debris Burning	4108	27
Equipment Use	360	2
Lightning	70	<1
Miscellaneous	1250	9
Railroad	110	1
Smoking	364	2
Total	14,982	

(Source: Kentucky Division of Forestry www.forestry.ky.gov/programs/firemanage/Fire+Statistics.htm)

BRUSH: A collective term that refers to stands of vegetation dominated by shrubby, woody plants, or low-growing trees, usually of a type undesirable for livestock or timber management.

BRUSH FIRE: A fire burning in vegetation that is predominantly shrubs, brush, and shrub growth.

Hazard Profile Ranking for 12 Natural Hazards in Louisville Metro

The Risk Matrix provides a qualitative assessment of various hazards that could occur.

SEVERE RISK HAZARDS	Flooding Severe Thunderstorms
HIGH RISK HAZARDS	Hailstorm Tornado
MODERATE RISK HAZARDS	Earthquake Severe Winter Storms
LIMITED RISK HAZARDS	Dam Failure Extreme Heat Karst/Sinkhole Landslides Wildfire
LOW RISK HAZARDS	Drought